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Bulletin No. 129 - Codling Moth Studies in 1911: The Driving Spray Under Excessively Wormy Conditions

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EXPERIMENT STATION

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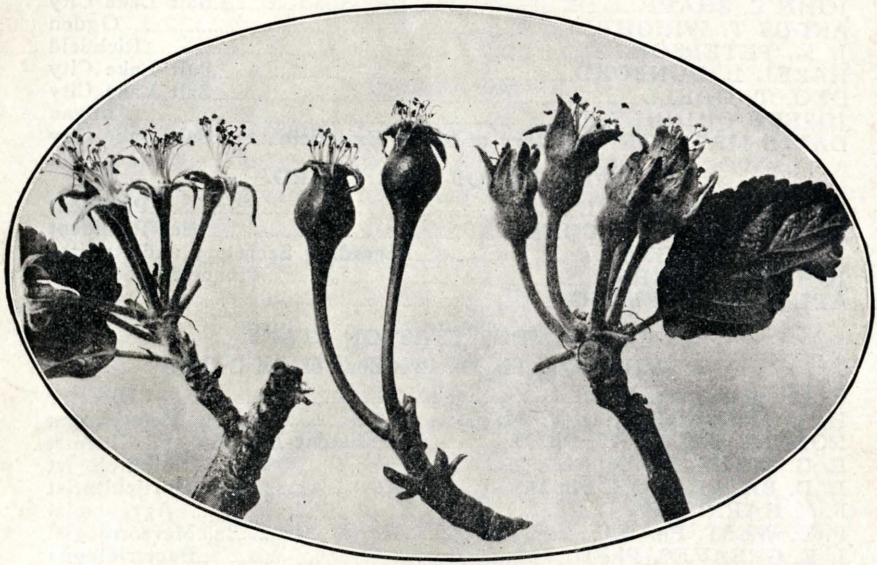

Codling Moth Studies in 1911

The Driving Spray Under Excessively Wormy Conditions

BY

E. D. BALL and W. M. BALL

Logan, Utah, November, 1913

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Codling Moth Studies in 1911

The Driving Spray Under Excessively Wormy Conditions

By E. D. BALL and W. M. BALL

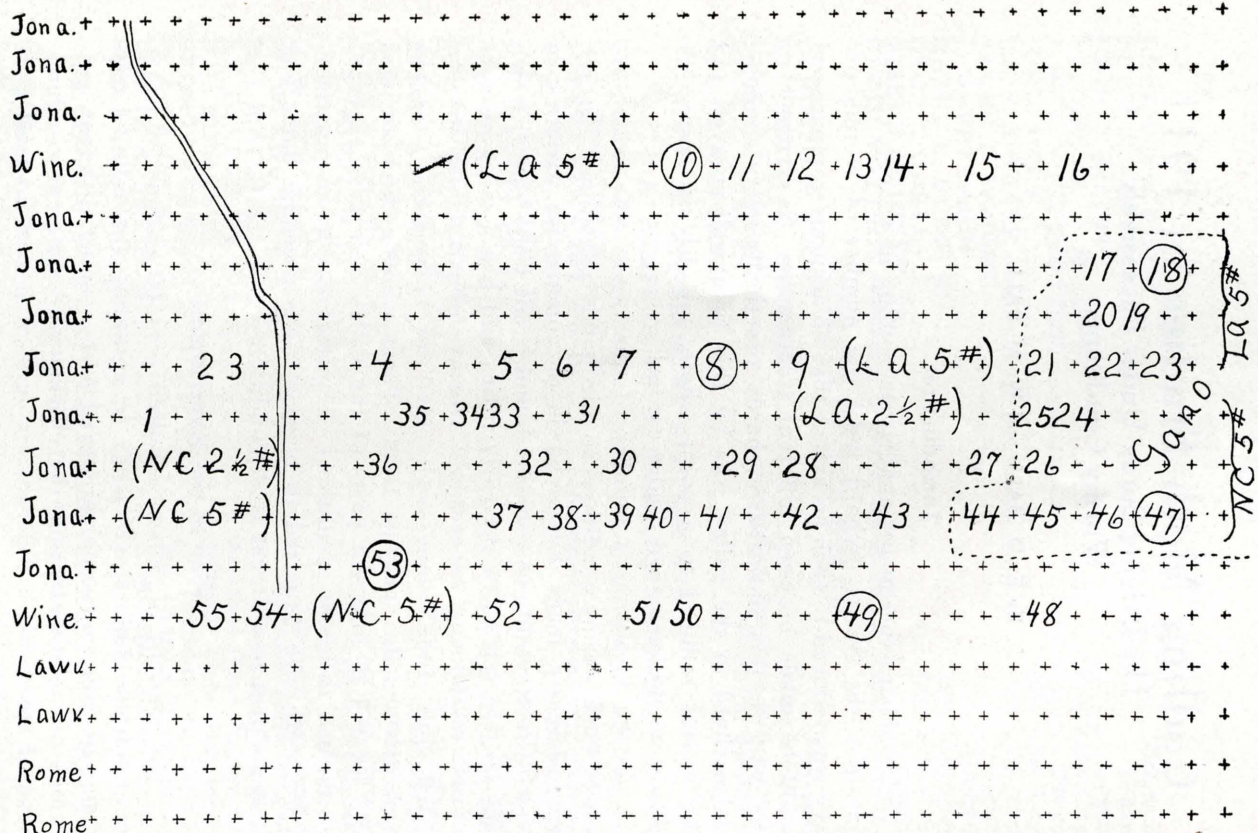
Introduction.

Spraying experiments against the codling moth were carried on upon the Smart orchard until the number of worms per tree was reduced to such an extent that no accurate comparisons could be made between different treatments. As a result of the work on this and other orchards, practically every commercial orchard in the valley was by this time well sprayed and the worms reduced to a point where one driving spray per season would keep them under control.

In the meantime a number of questions arose which required very wormy conditions to adequately investigate. Search was therefore made for orchards of commercial varieties in which these conditions could be found. Salt Lake valley, which was largely settled in the early fifties and has a large number of old, mixed and exceedingly wormy orchards, was investigated, and three young, well cared for commercial orchards were selected for spraying tests. These were of different ages and located in different parts of the valley and were expected to furnish different conditions of infestation for comparison. They were also expected to blossom on succeeding dates and to be subject to different frost conditions.

Plan of the Experiments.

The amount of poison required per 100 gallons of water to obtain the highest efficiency in spraying, the relative efficiency of different combinations of sprays under different conditions of worminess, and the efficiency of different combinations of sprays with different amounts of poison, as well as a comparison of a new compound with a standard brand were the three main problems attacked.



The Nokes Orchard.—Showing the distribution of the varieties, the method of spraying, and the distribution of the experimental trees.

The poisons used were Swift's Lead Arsenate, (this brand has been used throughout all experiments), and a new compound* which a manufacturing company was preparing to place on the market. The Lead Arsenate carried about 14 per cent arsenic oxide, while the new compound carried about 21 per cent.

Each poison was used in two strengths, 5 lbs. and 2½ lbs. to the 100 gallons of liquid. Three separate times of early spraying were tested alone and in combination, making six different combinations of sprays besides checks. Each orchard contained at least three of the standard varieties of apples, on each of which the six combinations were tried in each of the four poison series, with the exception of a few cases where there were not enough trees of a given variety. These amounted in all to 57 separate tests on 145 trees, involving the counting and careful examination of over 70,000 apples in the first brood alone. Additional combinations and more trees were introduced in the second brood, still further increasing the work.

The Orchards Used.

The Stillman Orchard is located on the higher slopes of the east side of the valley. It was ten years old, clean cultivated and well cared for. There were four varieties of apples, Gano, Jonathan, Winesap and Rome, with peach or cherry fillers between the trees in the row, and also between the rows. A number of the apple trees had died out, apparently from "collar rot," so that there were not enough of any one kind to carry on all the tests. Accordingly only the 5-lb. strengths and the first two sprays were used.

The Woodbury Orchard is located in the low, flat central part of the valley on heavy soil. This orchard was seven years old, clean cultivated, and well pruned. There were forty trees in a row; seven rows of Gano, six of Jonathan, and two of Winesap. Owing to the small number of rows only the 5-lb. strengths were used on the Winesaps.

*The company desired a thorough test made before placing the compound on the market and offered to finance a test. A combination of this test with the above experiments was arranged, thus making possible one of the largest and most complete spraying tests ever carried out. As the result of these tests was decidedly unfavorable the compound will not be placed on the market, so the name is withheld.

NOTE.—For a diagram of the Woodbury orchard see page 300.

The Nokes Orchard is located near the upper end of the valley, on a sandy soil near the river, but on higher rolling land. It was a clean, cultivated, well kept, ten-year-old orchard. This orchard contained almost 650 trees, over one-half of which were Jonathan. The remainder was made up mostly of Ben Davis* and Winesap. The Jonathan was the only variety on which it was possible to carry out all the tests.

The orchards came into blossom and were sprayed in the order given. Owing to very stormy weather and other delays the spraying was delayed so that the Nokes orchard was not reached as soon as it should have been, and as a result some of the earlier calyx cups were closing when the first spray was applied, and many were entirely closed before the second application was finished.

Number of Apples Per Tree and Relative Worminess of the Orchards Used.

All three orchards blossomed abundantly and everything pointed to heavy and uniformly distributed crops. A severe storm, however, swept the entire country just at this time, freezing a large number of the first buds and thus seriously reducing the number of apples per tree. The injury was greatest on the earlier blossoms, so the Stillman orchard was the most seriously injured, especially on the early blooming Jonathans. The Nokes orchard, blooming later, was only slightly injured, while the Woodbury orchard was intermediate in this respect, but as the trees of this orchard were small, and just coming into good bearing, the result was a very light crop.

As is usual, the frost injury was not uniform in distribution, some trees were left with fair crops, while others were almost stripped, which made it harder to spray and a much more difficult task to select check trees of uniform bearing. An average of all the trees counted in each orchard gives the average number of apples per tree shown in table A. This is probably above the actual average, as the trees selected were as far as possible bearing a fairly uniform amount of fruit.

*Ben Davis and Gano were used interchangeably, and all reported in the table as Gano.

Table A.—Expected Worminess if Unsprayed.

Orchard	Avg. No. Apples per tree, in the beginning	Avg. No. first brood worms on unsprayed trees	Avg. % wormy apples first brood	Est. No. worms per apple if unsprayed
Stillman	465	311	68	7
Woodbury	315	120	38	4
Nokes	694	100	14	1½

The average number of first brood worms is taken from the unsprayed trees in the experiments, and this accurately represents the conditions that would have existed provided the orchards had not been sprayed. A large number of the first brood worms on the unsprayed trees were caught under the bands and many of the rest scattered to the many sprayed trees surrounding them, so that the unsprayed trees do not represent the conditions that would have existed in the orchard at the end of the season if it had not been sprayed. This condition can be fairly accurately estimated, however. Assuming that the second brood is ten times as large as the first (and it was even more than that in Salt Lake valley that year), then if there were 68 worms in the Stillman orchard to 100 apples in the first brood there would have been without spraying 680 worms to 100 apples in the second brood, or approximately 7 worms to an apple as shown in the last column of the table.

The per cent of worminess shown in the table does not agree with that found in the summaries, as the latter are based on the unsprayed trees only, while the above is based on the average of all the counted trees. In the Stillman orchard one check with over 2,000 apples made the average too high, while in the Woodbury orchard two checks with scarcely 100 apples apiece made the average too low. These variations were largely due to the fact that the unsprayed trees had to be selected before spraying began, and consequently, before frost damage could be determined, all other checks were selected later and were more uniform in bearing and more nearly representative of orchard conditions.

The rates of expected worminess in the second brood shown in table A held good for the Stillman and Nokes orchards,

TABLE No. 1—STILLMAN ORCHARD, L. A. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
12	G	62	0	2	2	1	4	5	1	6	7	1-1-0
5	J	163	0	5	5	1	38	39	1	43	44	
27	W	1119	0	4	4	0	45	45	0	49	49	
26	R	168	0	10	10	1	40	41	1	50	51	
Avg.		378	0	5	5	1	32	33	1	37	38	
13	G	456	1	49	50	10	102	112	11	151	162	1-0-0
6	J	265	1	56	57	7	62	69	8	118	127	
24	W	314	0	14	14	0	68	68	0	82	82	
23	R	1026	0	23	23	2	184	186	2	207	209	
Avg.		515	1	35	36	5	104	109	6	139	145	
11	G	226	22	16	38	51	29	80	73	45	118	0-1-0
7	J	153	13	12	25	25	30	55	38	42	80	
22	W	192	0	5	5	2	32	34	2	37	39	
25	R	289	2	23	25	21	65	86	23	88	111	
Avg.		215	9	14	23	25	39	64	34	53	87	
14	G	58	50	1	51	4	0	4	54	1	55	0-0-0
1	J	29	5	2	7	13	0	13	18	2	20	
16	W	2275	814	175	989	757	150	907	1571	325	1896	
28	R	243	183	13	196	35	7	42	218	20	238	
Avg.		650	263	48	311	202	39	241	465	87	552	

but the Woodbury orchard was much wormier in comparison than expected, as in this orchard by far the largest amount of the new compound, and especially of half strengths was used, and the first brood moths from these rows spread to the lead arsenate rows in the second brood and made them much wormier than they would otherwise have been.

Method of Spraying.

The Stillman orchard was sprayed with a Bean Torrent (double acting) pump with a pressure of 150-200 lbs. Two

TABLE No. 2—STILLMAN ORCHARD, N. C. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
10	G	91	7	51	58	11	17	28	18	68	86	1-1-0
3	J	92	0	29	29	7	38	45	7	67	74	
18	W	837	18	133	151	30	218	248	48	351	399	
20	R	366	5	65	70	4	121	125	9	186	195	
Avg.		347	7	69	77	13	98	112	21	168	189	
8	G	64	7	29	36	14	14	28	21	43	64	1-0-0
4	J	268	3	51	54	21	110	131	24	161	185	
15	W	889	20	125	145	136	349	485	156	474	630	
21	R	276	2	55	57	3	80	83	5	135	140	
Avg.		374	8	65	73	44	138	182	52	203	255	
9	G	168	79	16	95	52	8	60	131	24	155	0-1-0
2	J	155	11	42	53	54	44	98	65	86	151	
17	W	1961	550	141	691	405	211	616	955	352	1307	
19	R	153	66	26	92	26	9	35	92	35	127	
Avg.		609	176	56	233	134	68	202	311	124	435	
14	G	58	50	1	51	4	0	4	54	1	55	0-0-0
1	J	29	5	2	7	13	0	13	18	2	20	
16	W	2275	814	175	989	757	150	907	1571	325	1896	
28	R	243	183	13	196	35	7	42	218	20	238	
Avg.		650	263	48	311	202	39	241	465	87	552	

outfits were used in the Woodbury orchard, a Meyers double acting with a pressure of 140-160 lbs., and a Pomona barrel outfit, with a pressure of from 120-160 lbs. In the Nokes orchard the same Meyers was used, and also a Bean Magic with a pressure of 140-160 lbs. Each outfit was equipped with 25 or 30 ft. of ½ inch 7-ply hose, a cut-off and a 10 ft. bamboo extension pole, a 45 degree angle and a Bordeaux nozzle set as wide as it would throw a flat spray. All spraying was done from the top of step ladders that placed the operators on a level with the tops of the trees. Each tree was sprayed from

TABLE No. 3—WOODBURY ORCHARD, L. A. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
61	G	433	0	10	10	1	95	96	1	105	106	1-0-1
40	J	193	0	7	7	4	66	70	4	73	77	
8	W	144	0	6	6	0	32	32	0	38	38	
Avg.		257	0	8	8	2	64	66	2	72	74	
62	G	968	0	34	34	3	243	246	3	277	280	1-1-0
38	J	241	1	14	15	0	108	108	1	122	123	
12	W	130	1	20	21	1	44	45	2	64	66	
Avg.		446	1	23	23	1	132	133	2	155	156	
58	G	630	1	29	30	9	224	233	10	253	263	1-0-0
36	J	222	1	42	43	3	105	108	4	147	151	
4	W	244	0	54	54	0	103	103	0	157	157	
Avg.		365	1	42	42	4	144	148	5	186	190	
57	G	425	2	10	12	23	110	133	25	120	145	0-1-1
37	J	312	5	7	12	52	91	143	57	98	155	
2	W	163	3	12	15	2	17	19	5	29	34	
Avg.		300	3	10	13	26	73	98	29	83	111	
68	G	447	6	15	21	46	149	195	52	164	216	0-1-0
17	J	92	19	31	50	35	1	36	54	32	86	
13	W	235	6	24	30	7	84	91	13	108	121	
Avg.		258	10	23	34	29	78	107	39	101	141	
63	G	695	53	46	99	245	123	368	298	169	467	0-0-1
39	J	190	31	42	73	51	30	81	82	72	154	
9	W	240	41	32	73	56	46	102	97	78	175	
Avg.		375	42	40	82	117	66	184	159	106	266	
67	G	335	133	30	163	113	16	129	246	46	192	0-0-0
35	J	400	44	94	138	166	69	235	210	163	373	
20	J	114	42	22	64	30	12	42	72	34	106	
14	W	263	144	33	177	62	10	72	206	43	249	
1	W	97	34	23	57	28	2	30	62	25	87	
Avg.		242	79	40	120	80	22	102	159	62	222	

TABLE No. 4—WOODBURY ORCHARD, L. A. 2½ LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
65	G	128	0	3	3	0	43	43	0	46	46	1-0-1
16	J	199	1	25	26	2	103	105	3	128	131	
Avg.		164	1	14	15	1	73	74	2	87	89	
56	G	538	0	19	19	10	168	178	10	187	197	1-1-0
28	J	353	1	36	37	3	144	147	4	180	184	
Avg.		446	1	28	28	7	156	163	7	184	191	
64	G	733	3	38	41	18	275	293	21	313	334	1-0-0
23	J	192	1	58	59	6	86	92	7	144	151	
Avg.		463	2	48	50	12	181	196	14	229	243	
59	G	515	4	16	20	69	160	229	73	176	249	0-1-1
24	J	231	9	8	17	52	68	120	61	76	137	
Avg.		373	7	12	19	61	114	175	67	126	193	
66	G	211	3	13	16	31	76	107	34	89	123	0-1-0
31	J	152	6	19	25	32	53	85	38	72	110	
Avg.		182	5	16	21	32	65	96	36	81	117	
69	G	331	102	42	144	111	38	149	213	80	293	0-0-1
41	J	238	58	38	96	107	19	126	165	57	222	
Avg.		285	80	40	120	109	29	138	189	69	258	
67	G	335	133	30	163	113	16	129	246	46	292	0-0-0
35	J	400	44	94	138	166	69	235	210	163	373	
20	J	114	42	22	64	30	12	42	72	34	106	
Avg.		283	73	49	122	103	32	135	176	81	257	

all four angles and from above and below until the operator was satisfied that the spray had been driven straight into every single blossom.

To accomplish these results usually requires the application of almost two gallons of liquid to every three bushels of apples

TABLE No. 5—WOODBURY ORCHARD, N. C. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
48	G	425	8	63	71	66	159	225	74	222	296	1-0-1
21	J	216	6	59	65	36	76	112	42	135	177	
10	W	120	1	42	43	6	57	63	7	99	106	
Avg.		254	5	55	60	36	97	133	41	152	193	
47	G	424	8	71	79	39	159	198	47	230	277	1-1-0
5	J	162	4	49	53	22	70	92	26	119	145	
11	W	164	2	39	41	4	88	92	6	127	133	
Avg.		250	5	53	58	22	106	127	26	159	185	
53	G	934	31	151	182	83	397	480	114	548	662	1-0-0
27	J	230	7	85	92	38	72	110	45	157	202	
3	W	185	18	84	102	0	60	60	18	144	162	
Avg.		450	19	107	125	40	176	217	59	283	342	
52	G	862	45	61	106	147	309	456	192	370	562	0-1-1
32	J	251	20	38	58	61	60	121	81	98	179	
15	W	261	29	40	69	60	59	119	89	99	188	
Avg.		458	31	46	78	89	143	232	121	189	310	
51	G	425	60	33	93	146	81	227	206	114	320	0-1-0
22	J	137	35	47	82	33	15	48	68	62	130	
6	W	214	26	61	87	57	47	104	83	108	191	
Avg.		259	40	47	87	79	48	126	119	95	214	
43	G	290	124	50	174	79	23	102	203	73	276	0-0-1
26	J	129	50	17	67	47	9	56	97	26	123	
7	W	100	34	12	46	36	13	49	70	25	95	
Avg.		173	69	26	96	54	15	69	123	41	165	

expected. In the first spray, however, there was no means of telling what blossoms were frosted and what were not, so all were sprayed, with the result that over twice as much liquid was used as the final results in apples would warrant. By the

TABLE No. 6—WOODBURY ORCHARD, N. C. 2½ LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
46	G	192	1	17	18	44	69	113	45	86	131	1-0-1
18	J	68	7	31	38	14	5	19	21	36	57	
Avg.		130	4	24	28	29	37	66	33	61	94	
54	G	730	16	129	145	92	297	389	108	426	534	1-1-0
30	J	269	12	53	65	57	96	153	69	149	218	
Avg.		500	14	91	105	75	197	271	89	288	376	
49	G	605	15	66	81	191	128	319	206	194	400	1-0-0
29	J	310	16	101	117	71	99	170	87	200	287	
Avg.		458	16	84	99	131	114	245	147	197	344	
44	G	346	50	35	85	147	63	210	197	98	295	0-1-1
25	J	191	58	40	98	59	22	81	117	62	179	
Avg.		269	54	38	92	103	43	146	157	80	237	
45	G	214	42	61	103	32	53	85	74	114	188	0-1-0
33	J	96	11	31	42	18	22	40	29	53	82	
Avg.		155	27	46	73	25	38	63	52	84	135	
50	G	471	82	72	154	223	63	286	305	135	440	0-0-1
19	J	284	97	71	168	63	31	94	160	102	262	
Avg.		378	90	72	161	143	47	190	233	119	351	

time of the second spray the frosted blossoms were off and the amount of liquid used followed closely to the above rule.

Method of Selecting Test Trees and Checks.

The unsprayed checks were selected before spraying commenced, care being taken to select trees of average size and bearing, well distributed through the orchard and including each variety under test. As small a number as consistent with accuracy were used so as not to affect results in the second

TABLE No. 7—NOKES ORCHARD, L. A. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
20	G	888	0	1	1	9	40	49	9	41	50	1-0-1
2	J	361	0	2	2	11	66	77	11	68	79	
14	W	143	0	1	1	0	4	4	0	5	5	
Avg.		464	0	1	1	7	37	43	7	38	44	
19	G	740	1	1	2	2	41	43	3	42	45	1-1-0
5	J	446	2	1	3	7	25	32	9	26	35	
16	W	153	0	0	0	0	6	6	0	6	6	
Avg.		446	1	1	2	3	24	27	4	25	29	
17	G	1409	1	1	2	18	52	70	19	53	72	1-0-0
9	J	995	0	8	8	11	36	47	11	44	55	
11	W	282	0	3	3	1	7	8	1	10	11	
Avg.		895	0	4	4	10	32	42	10	36	46	
22	G	2021	67	15	82	308	220	528	375	235	610	0-1-1
3	J	546	22	10	32	104	78	182	126	88	214	
13	W	18	1	0	1	1	1	2	1	1	3	
Avg.		862	30	8	38	138	100	237	168	108	275	
23	G	725	35	23	58	136	77	213	171	100	271	0-1-0
7	J	532	36	27	63	85	52	137	121	79	200	
12	W	144	2	2	4	2	4	6	4	6	10	
Avg.		467	24	17	42	74	44	119	98	61	160	
21	G	1270	118	26	144	334	117	451	452	143	595	0-0-1
4	J	662	23	18	41	86	78	164	109	96	205	
15	W	91	3	0	3	7	3	10	10	3	13	
Avg.		674	48	15	63	142	66	208	190	81	271	
18	G	606	77	19	96	212	48	260	289	67	356	0-0-0
47	G	1617	242	76	318	762	239	1001	1004	315	1319	
8	J	418	44	18	62	73	40	113	117	58	175	
53	J	373	56	12	68	170	71	241	226	83	309	
10	W	76	3	1	4	2	11	13	5	12	17	
49	W	611	43	9	52	222	114	336	265	123	388	
Avg.		617	78	23	100	240	87	327	318	110	427	

TABLE No. 8—NOKES ORCHARD, L. A. 2½ LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
35	J	425	0	6	6	26	44	70	26	50	76	1-0-1
33	J	517	5	11	16	47	68	115	52	79	131	1-1-0
1	J	394	1	7	8	46	94	140	47	101	148	1-0-0
No.												0-1-1
31	J	586	52	14	66	167	63	230	219	77	296	0-1-0
34	J	689	55	8	63	155	74	229	210	82	292	0-0-1
8	J	418	44	18	62	73	40	113	117	58	175	0-0-0
53	J	373	56	12	68	170	71	241	226	83	309	
Avg.		396	50	15	65	122	56	177	172	71	242	

brood.* The checks and trees from which the first spray was to be omitted were marked with a warning flag, and the rest of the orchard was sprayed as in ordinary commercial work. The same method was used in the second spray, warning flags were put on the checks and test trees that were not to receive this spray, and all others were sprayed alike. Test trees that received two sprayings were not selected until after this spray was applied. By not selecting the test trees until the sprays

*The relative value of this method of checking, and the use of a block of unsprayed trees, will be discussed in another publication.

TABLE No. 9—NOKES ORCHARD, N. C. 5 LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
25	G	1386	69	21	90	339	200	539	408	221	629	1-0-1
40	J	628	25	10	35	181	118	299	206	128	334	
48	W	341	9	9	18	26	112	138	35	121	156	
Avg.		785	34	13	48	182	143	325	216	157	373	
24	G	1466	92	36	128	459	268	727	551	304	855	1-1-0
39	J	922	27	21	48	266	149	415	293	170	463	
51	W	634	15	8	23	52	200	252	67	208	275	
Avg.		1007	45	22	66	259	206	465	304	227	531	
26	G	1597	119	40	159	466	333	799	585	373	958	1-0-0
43	J	1063	40	24	64	375	225	600	415	249	664	
54	W	584	4	24	28	38	183	221	42	207	249	
Avg.		1081	54	29	84	293	247	540	347	276	624	
46	G	1078	98	22	120	528	201	729	626	223	849	0-1-1
38	J	637	60	7	67	241	105	346	301	112	413	
52	W	117	17	4	21	34	24	58	51	28	79	
Avg.		611	58	11	69	268	110	378	326	121	447	
44	G	898	73	10	83	399	134	533	472	144	616	0-1-0
37	J	397	44	17	61	166	78	244	210	95	305	
55	W	617	76	18	94	172	148	320	248	166	414	
Avg.		637	64	15	81	246	120	366	310	135	445	
45	G	1797	206	57	263	735	246	981	941	303	1244	0-0-1
42	J	944	49	11	60	267	126	393	316	137	453	
50	W	217	16	3	19	85	26	111	101	29	130	
Avg.		986	90	24	114	362	133	495	453	156	609	

are on, all possibility of discrimination in spraying is avoided, and by delaying the selection until all frosted blossoms have dropped, much more uniform bearing trees can be selected. The third spray was applied only to the test trees. Bands were

TABLE No. 10—NOKES ORCHARD, N. C. 2½ LBS.

Tree No.	Variety	Total Apples	1st BROOD Wormy Apples			2d BROOD Wormy Apples			YEAR TOTAL Wormy Apples			Sprays
			Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	1st-2d-3d
28	J	772	46	20	66	149	82	231	195	102	297	1-0-1
32	J	293	24	20	44	117	49	166	141	69	210	1-1-0
36	J	1561	105	52	157	466	333	799	571	385	956	1-0-0
27	J	723	58	18	76	243	128	371	301	146	447	0-1-1
30	J	510	68	16	84	186	97	283	254	113	367	0-1-0
29	J	867	72	20	92	259	142	401	331	162	493	0-0-1

placed on all checks and test trees, the number of worms caught in this way probably about balancing the extra worms appearing in the orchard on account of the checks and omitted sprays from test trees, thus leaving the orchard in about the same condition as it would have been if all trees had been sprayed.

Sprays and Spray Combinations Used.

Three times of early spraying were tested alone and in combination with others. **The first spray,** applied just as soon after the blossoms fell as possible. **The second spray,** applied about seven to ten days later, and a **third spray,** applied about two weeks later or at the time the worms were entering the fruit.

Late sprays were applied at the time second brood worms were entering. In the tables "1-0-0" indicates the first spray only was applied, "0-1-0" the second only, and "1-1-0" that the

first two were applied. From this explanation other combinations will be readily understood.

Records Kept.

All trees in the experiment were examined twice a week, the band worms counted and killed, windfalls picked up and examined for wormy and sound apples, the wormy ones examined to see whether the worm entered the calyx or the side of the apple. At the end of the first brood all the trees were gone over and every apple examined to see whether calyx wormy, side wormy or sound, and so recorded. (The wormy apples were left on the trees.) At picking time the apples were examined in the same way again.

The records of the first brood for all orchards is approximately correct. In the Stillman and Woodbury orchards in the second brood many of the apples on the unsprayed trees, and some apples on the less efficiently sprayed ones, had more than one worm each. These were only recorded once. If a worm went in the calyx it was set down as calyx wormy, although it might have had one or two entering the side also. The column of calyx wormy then shows every apple that had a calyx worm, while the side wormy column would not contain apples that had side worms but also calyx worms, and apples with two or more side worms were only entered once. This doubling up of worms on the check trees made it impossible to figure percentages in these cases, and also reduces the efficiency shown, below that actually obtained.

Results of the Tests.

The results of the season's work are shown in tables Nos. 1 to 10. The individual tree records are given by orchards, arranged in groups according to the treatment they received. The orchards are arranged in the order of blossoming, this being the order of spraying. The S. orchard was first sprayed May 14th and 15th, the W. orchard from May 17th to 23d, while the N. orchard was ready May 19th, but spraying was not commenced until May 24th, and not finished until May 30th.

The poisons used are arranged in the order of their efficiency, Lead Arsenate 5 lbs. proved to be the most efficient—followed by Lead Arsenate 2½ lbs., N. C. 5 lbs., and N. C. 2½ lbs., in the order named.

The spraying combinations are also arranged in the order of their efficiency in protecting the orchard through the entire season.

The first brood results as given are made up of all wormy apples found on the ground up to August 1st, together with all wormy apples on the trees at that time, excepting only, just entering, worms which at this date were very few in number and were the first ones of the second brood.

Results in the First Brood, Using Lead Arsenate 5 Lbs.

The results in the first brood on an orchard are not affected by check trees unsprayed,* by treatment of adjacent blocks or by the number of worms present under any ordinary** conditions. It is therefore possible to compare first brood results with considerable certainty of their accuracy within the limits of experimental error.

A study of the first brood columns of tables Nos. 1, 3, and 7, show that with the standard spray the calyx worms were practically eliminated wherever the first spray was applied. Out of twenty-six trees, seventeen had no calyx wormy, and only one tree had more than one, and that one was in the last orchard sprayed, which was sprayed too late for the best results. Following down the column it is seen that the calyx worms increase as the first and second sprays were omitted, and that on the unsprayed checks the great majority of the worms went in at the calyx. The greater majority of the first brood worms and nearly as large a per cent of the second brood go into the calyx ends of the apples, and it is against these worms that the first two sprays are directed. Any value that

*A single sprayed tree in the midst of an unsprayed orchard would give just as good results in the first brood as if the whole orchard were sprayed.

**It is, of course, only under exceedingly wormy conditions that there would be anywhere near as many first brood worms as there were apples on the tree. A heavy crop followed by a very light one might produce this condition. The senior writer observed a case of this kind where there were several worms to an apple in the first brood. (See Bulletin 67, Bureau of Entomology, U. S. D. A., p. 73, 1907.) In table No. 11 it will be noticed that the unsprayed trees in the first two of the orchards averaged one-half wormy in the first brood, while the third one was only one-sixth wormy. Tree No. 14 in the Stillman orchard was probably the only one on which there was more than one worm to an apple. On this tree nearly every apple had a worm in the calyx, and were so counted, while a part of them had other worms in the sides.

they have against the side worms is a welcome addition to their primary value. An examination of the side wormy columns of first brood results in tables Nos. 1, 3, and 7, will show a wide variation in relative value of the early sprays against the side worms. On the S. orchard, which was sprayed very early, the first spray left a larger number of side worms than the second, while on the N. orchard, where the first spray was late, it left the cleanest fruit of any spray applied. The combinations of early sprays showed little increased value against the calyx worms as each one alone was capable of killing nearly all of them. These combinations are, however, seen to be more efficient in every case in destroying the side worms, and usually give better results in the second brood.

Second Brood Results, with L. A. 5 Lbs.

The results in the second brood are never as satisfactory as those in the first, as there is always more or less interference as the result of check trees, trees with less favorable spray and outside influences. If the total number of worms is small as compared with the total number of apples, the results are only slightly affected. If, on the other hand, the number of worms is nearly equal to, or exceeds the number of apples, the results must be interpreted accordingly. For example, in an orchard where the trees average 1000 apples apiece a sprayed tree might have 50 wormy apples in the first brood, while an unsprayed check had 500. If the worms increase ten times in the second brood the sprayed tree would have 500 second brood worms. The unsprayed tree at the same date would have 5,000 wormy, but instead it had only 500 apples left to get wormy, so could only have 500 wormy apples if every apple stayed on the tree till a worm entered, which does not happen, so that there would actually be a less number of wormy apples on an unsprayed tree than on a sprayed one.

In two of these orchards the check trees averaged one-half wormy in the first brood, so could not have any increase in the second brood. On some of the trees most of the wormy apples fell off in August and September, while the few that remained had a number of worms apiece. In the N. orchard, however, the check trees had apples enough for the worms in most all cases, so that the results obtained there may be compared directly.

In spite of the excessive worminess of these orchards, the calyx results in the second brood were remarkably good. A glance down the second brood calyx columns in tables Nos. 1, 3, and 7, show that the trees that received the first spray are almost free from calyx wormy, averaging between two and three per tree in the first two orchards sprayed, and only seven per tree in the one that was sprayed too late.

Results Measured in Terms of Efficiency.

Table No. 11, a summary of tables Nos. 1, 3, and 7, gives the average results obtained by using L. A. 5 lbs. for each spray combination in each orchard. These results are expressed in per cent wormy, and also in terms of efficiency.

The per cent wormy is the ordinary method of expressing the results of a spraying experiment, and will enable anyone to compare these results with those of other writers, and also to judge of the actual results in the orchard. By the "Efficiency"* of a spray is meant its actual killing power. For example, in the Woodbury orchard, table No. 3, the average number of calyx wormy in the second brood with the 1-0-1 spray was 2. The average number of calyx wormy on the unsprayed trees (0-0-0) in the same table, was 80, showing that an average of 78 out of 80 calyx worms had been killed, or 98 per cent, which is the first second brood figure in table 11.

*The efficiency of a given spray is a much better measure of its value than the per cent of sound or wormy apples in the orchard. The per cent of wormy apples will naturally fluctuate up and down with the size of the crop. Suppose, for example, that a given orchard averaged 200 worms per tree each year; when that tree bore 2,000 apples it would be only ten per cent wormy; but with a light crop of 200 apples, it would be all wormy. And yet there would have been the same number of worms in the orchard each year. If, on the other hand, a spray that would kill 80 per cent was applied to these worms, it would not make any difference whether the worms were on 200 apples or distributed among 2,000—it would kill 80 per cent of them and get credited with 80 per cent efficiency in both cases, while the orchards would be 2 per cent wormy in one case and 20 per cent in the other. Of course where there is more than one worm to an apple on the unsprayed trees it is not possible to accurately calculate the total efficiency for the year. Even here, however, the first brood efficiency can be shown and usually the calyx efficiency for the year. The real efficiency in the second brood is directly proportional to that shown in the first, as will be seen by comparing results where there was no doubling up of worms, as in previous tests, and in the Nokes orchard in these experiments. Therefore, the comparative efficiency of any series of sprays or the actual efficiency of any given spray can be determined by its efficiency against the first brood of worms.

It will be noted that in computing efficiency only the unsprayed trees of the same varieties as the sprayed ones were used in the calculations, as for example, in tables Nos. 4 and 6 only the Gano and Jonathan checks were used, as only those varieties were in this test.

The average efficiency of the first three combinations (the ones in which the first spray was used), in table 11 is seen to be very high. The first brood calyx efficiency varying between 99 and 100 per cent, while in the second brood it varies between 96 and 99 per cent. The total efficiency in the first brood is quite high in the S. and N. orchards, only falling below 96 per cent in one case. It appears to be lower in the W. orchard, but this is due to the doubling up of the first brood worms on some of the checks in this orchard; three out of the five check trees being over one-half wormy in the first brood.

The total efficiency in the second brood cannot be measured directly in the W. or S. orchards, where there was more than one worm to an apple on the checks, but in the N. orchard the average of the three combinations carrying the first spray is seen to be 89 per cent, which is a very high second brood efficiency record.

The average efficiency of the spray combinations lacking the first spray is seen to be strikingly lower than those carrying it, and there is an even greater difference between the calyx value of the second and third sprays than between the first and second.

Relative Efficiency of the New Compound as Compared with a Standard Lead Arsenate.

Tables Nos. 2, 5 and 9 present the results of the use of the new compound used in 5 lb. strength. These are summarized and shown in terms of efficiency in table 13, which can be compared directly with table 11 for Lead Arsenate. On examination it will be seen that the efficiency is everywhere lower than with Lead Arsenate. In the first brood calyx it is about three-fourths as efficient, while in the second brood calyx it is only a little over one-half as efficient as the standard poison. The total efficiency was still lower in comparison with Lead Arsenate than that in the calyx, indicating a low adhesive power.

Tables Nos. 6 and 10 give the results of using the N. C. at the rate of 2½ lbs. These are summarized in table 14, from which it is seen that by reducing the amount of poison one-half the efficiency was reduced nearly as much.

A study of the original tables and their summaries shows that this low efficiency of the N. C. is universal. There was only one single tree in the entire number but that had calyx wormy apples in the first brood. This was in the first orchard sprayed, where the calyx cups were wide open at spraying time, and in this orchard the best results with this compound were secured. In the last orchard sprayed, where the apples were quite well formed and the calyx cups closing at spraying time, the results were all very poor. This is hard to understand, as the spraying on both orchards was the same, and the Lead Arsenate results on the two orchards vary scarcely one per cent. The N. C. apparently had little penetrating power in a closing calyx.

The Amount of Poison to Use.

Tables Nos. 4 and 8 give the results of the use of 2½ lbs. of Lead Arsenate. These are summarized in table 12. A comparison of these tables with the L. A. 5 lbs. tables will show that the reduction in the amount of poison resulted in a slight but almost uniform reduction in the efficiency of the sprays. The difference was much more marked where only a single spray was applied than where they were combined. Two sprays of the weaker strength were, however, not as efficient as the one 5 lb. spray.

The first spray alone in 5 lb. strength gave an average calyx efficiency of 98 per cent for the year, while the 2½ lb. spray in combination gave only 92 per cent and 83 per cent efficiency. In the same way the second spray alone gave in 5 lb. strength 73 per cent calyx efficiency for the year, while the second spray, with a later one in 2½ lb. series, only gave 41 per cent efficiency. The cost of the poison in the 5 lb. spray is only about one-half cent per bushel. It is certainly poor economy to attempt to save one-fourth of a cent per bushel on the cost of the poison and then lose a large per cent of the bushel through worms. The labor and equipment cost of spraying is much greater than the poison cost in any case, so that any attempt to cut down cost would preferably increase the amount of poison used and decrease the number of sprayings necessary.

TABLE No. 11—LEAD ARSENATE 5 LBS. SUMMARY.

Orchard	*Total Apples	% Wormy		1st BROOD				2d BROOD				YR. TOTAL				
				Calyx		Total		Calyx		Total		Calyx		Total		
		1st B.	Yr.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	
W ___	257	3	28	0	100	8	93	2	98	66	35	2	99	74	67	1-0-1
N ___	464	¼	10	0	100	1	99	7	97	43	87	7	98	44	90	
Avg. Efficiency_____				_____	100	_____	96	_____	98	_____	_____	_____	99	_____	____	
S ____	378	1	10	0	100	5	98	1	100	33	87	1	100	38	93	1-1-0
W ___	446	5	35	1	99	23	81	1	99	133	0	2	99	156	30	
N ____	446	½	6	1	99	2	98	3	99	27	92	4	99	29	93	
Avg. Efficiency_____				_____	99	_____	92	_____	99	_____	_____	_____	99	_____	____	
S ____	533	7	27	1	100	36	88	5	98	109	55	6	99	145	74	1-0-0
W ___	365	12	40	1	99	42	65	4	95	148	0	5	97	190	14	
N ____	895	½	5	0	100	4	96	10	96	42	87	10	97	46	89	
Avg. Efficiency_____				_____	100	_____	83	_____	96	_____	_____	_____	98	_____	____	

W	300	4	37	3	96	13	89	26	67	98	4	29	82	111	50	0-1-1
N	862	4	32	30	62	38	62	138	42	237	28	168	47	275	36	
Avg. Efficiency					79		76		55				65				
S	215	11	40	9	97	23	93	25	88	64	73	34	93	87	84	0-1-0
W	258	12	53	10	87	34	72	29	64	107	0	39	75	141	36	
N	467	9	34	24	69	42	58	74	69	119	64	98	69	160	62	
Avg. Efficiency					84		74		74				79				
W	375	22	72	42	47	82	32	117	0	184	0	159	0	266	0	0-0-1
N	674	9	40	48	38	63	37	142	41	208	36	190	40	271	37	
Avg. Efficiency					43		35		21				20				
S	650	48	85	263		311		202		241		465		552		0-0-0
W	242	50	92	79		120		80		102		159		222		
N	617	16	69	78		100		240		327		318		427		

*Average per tree.

TABLE No. 12—LEAD ARSENATE 2½ LBS. SUMMARY.

Orchard	*Total Apples	% Wormy		1st BROOD				2d BROOD				YR. TOTAL				
				Calyx		Total		Calyx		Total		Calyx		Total		
		1st B.	Yr.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	
W ___	164	9	54	1	99	15	88	1	99	74	45	2	99	89	65	1-0-1
N ____	425	1	18	0	100	6	91	26	79	70	60	26	85	76	69	
Avg. Efficiency_____				_____	100	_____	90	_____	89	_____	53	_____	92	_____	67	
W ___	446	6	43	1	99	28	77	7	93	163	0	7	96	191	26	1-1-0
N ____	517	3	25	5	90	16	75	47	61	115	35	52	70	131	46	
Avg. Efficiency_____				_____	95	_____	76	_____	77	_____	18	_____	83	_____	____	
W ___	463	11	53	2	97	50	59	12	88	196	0	14	92	243	6	1-0-0
N ____	394	2	38	1	98	8	88	46	62	140	21	47	73	148	39	
Avg. Efficiency_____				_____	98	_____	74	_____	75	_____	_____	_____	83	_____	____	

W	373	5	52	7	**90**	19	**84**	61	**41**	175	**0**	67	**62**	193	**25**	0-1-1
N																
Avg. Efficiency					**55**		**52**		**31**				**41**			
W	182	11	64	5	**93**	21	**83**	32	**69**	96	**29**	36	**80**	117	**56**	0-1-0
N	586	11	51	52	**0**	66	**0**	167	**0**	230	**0**	219	**0**	296	**0**	
Avg. Efficiency					**47**		**42**		**35**				**40**			
W	285	42	91	80	**0**	120	**2**	109	**0**	138	**0**	189	**0**	258	**0**	0-0-1
N	689	9	42	55	**0**	63	**3**	155	**0**	229	**0**	210	**0**	292	**0**	
Avg. Efficiency					**0**		**3**		**0**				**0**			
W	283	43	91	73		122		103		135		176		257		0-0-0
N	396	16	64	50		65		122		177		172		242		

TABLE No. 13—N. C. 5 LBS. SUMMARY.

Orchard	*Total Apples	% Wormy		1st BROOD				2d BROOD				YR. TOTAL				
				Calyx		Total		Calyx		Total		Calyx		Total		
		1st B.	Yr.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	
W ___	254	24	76	5	94	60	50	36	55	133	0	41	74	193	13	1-0-1
N ____	785	6	48	34	56	48	52	182	24	325	1	216	32	373	13	
Avg. Efficiency_____				_____	75	_____	51	_____	40	_____	_____	_____	53	_____	____	
S ____	347	22	54	7	97	77	75	13	94	112	54	21	96	189	66	1-1-0
W ___	250	23	74	5	94	58	52	22	72	127	0	26	83	185	17	
N ____	1007	7	53	45	42	66	34	259	0	465	0	304	4	531	0	
Avg. Efficiency_____				_____	78	_____	54	_____	55	_____	_____	_____	61	_____	____	
S ____	374	20	68	8	97	73	77	44	78	182	24	52	89	255	54	1-0-0
W ___	450	28	76	19	76	125	0	40	50	217	0	59	63	342	0	
N ____	1081	8	58	54	31	84	16	293	0	540	0	347	0	624	0	
Avg. Efficiency_____				_____	68	_____	31	_____	43	_____	_____	_____	51	_____	____	

W	458	17	68	31	61	78	35	89	0	232	0	121	25	310	0	0-1-1
N	611	11	73	58	26	69	31	268	0	378	0	326	2	447	0	
Avg. Efficiency					44		33		0				14			
S	609	38	71	176	33	233	25	134	34	202	16	311	33	435	21	0-1-0
W	259	34	82	40	50	87	27	79	1	126	0	119	25	214	4	
N	637	13	70	64	18	81	19	246	0	366	0	310	3	445	0	
Avg. Efficiency					34		24		12				20			
W	173	55	95	69	13	96	20	54	32	69	32	123	23	165	26	0-0-1
N	986	12	62	90	0	114	0	362	0	495	0	453	0	609	0	
Avg. Efficiency					7		10		16				12			
S	650	48	85	263		311		202		241		465		552		0-0-0
W	242	50	92	79		120		80		102		159		222		
N	617	16	69	78		100		240		327		318		427		

TABLE No. 14—N. C. 2½ LBS. SUMMARY.

Orchard	*Total Apples	% Wormy		1st BROOD				2d BROOD				YR. TOTAL				
				Calyx		Total		Calyx		Total		Calyx		Total		
		1st B.	Yr.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	Wmy.	% Eff.	
W ___	130	21	72	4	95	28	77	29	72	66	51	33	81	94	67	1-0-1
N ____	772	9	38	46	8	66	0	149	0	231	0	195	0	297	0	
Avg. Efficiency_____				_____	52	_____	39	_____	36	_____	_____	_____	41	_____	____	
W ___	500	21	75	14	81	105	14	75	27	271	0	89	49	376	0	1-1-0
N ____	293	15	72	24	52	44	32	117	4	166	6	141	18	210	13	
Avg. Efficiency_____				_____	67	_____	23	_____	16	_____	_____	_____	34	_____	____	
W ___	458	22	75	16	78	99	19	131	0	245	0	147	16	344	0	1-0-0
N ____	1561	10	61	105	0	157	0	466	0	799	0	571	0	956	0	
Avg. Efficiency_____				_____	39	_____	10	_____	0	_____	_____	_____	8	_____	____	

W ----	269	34	88	54	**26**	92	**25**	103	**0**	146	**0**	157	**11**	237	**8**	}	0-1-1
N ----	723	11	62	58	**0**	76	**0**	243	**0**	371	**0**	301	**0**	447	**0**	}	
Avg. Efficiency----					**13**		**13**		**0**				**6**				
W ----	155	46	87	27	**63**	73	**40**	25	**76**	63	**53**	52	**70**	135	**47**	}	0-1-0
N ----	510	16	72	68	**0**	84	**0**	186	**0**	283	**0**	254	**0**	367	**0**	}	
Avg. Efficiency----					**32**		**20**		**38**				**35**				
W ----	378	43	93	90	**0**	161	**0**	143	**0**	190	**0**	233	**0**	351	**0**	}	0-0-1
N ----	867	11	57	72	**0**	92	**0**	259	**0**	401	**0**	331	**0**	493	**0**	}	
Avg. Efficiency----					**0**		**0**		**0**				**0**				
W ----	283	43	91	73	-----	122	-----	103	-----	135	-----	176	-----	257	----	}	0-0-0
N ----	396	16	64	50	-----	65	-----	122	-----	177	-----	172	-----	242	----	}	

The Relative Value of Different Sprays Under Excessively Wormy Conditions.

Table No. 15 brings together the averages of tables Nos. 11-14, and shows the average efficiency of each spray alone and in combination.

The Stillman and Woodbury orchards presented such extremely wormy conditions that a spray that was successful here may be depended upon to do its share in controlling any ordinary infestation. The tests were arranged so that each spray was tested alone and in combination with at least one other. It may not be possible to estimate the real value of a spray where used alone, as sprays are applied either as calyx sprays or cover-sprays, and under severe infestation both are necessary to protect the fruit. Thus we see in table 15 that the most efficient combination used was one calyx spray and one cover spray (1-0-1), but this does not argue that these two sprays would be the two most effective used alone. The cover spray was in fact in every test the least effective spray used.

The value of a given spray is made up of at least four factors, each one of which must be separately measured and valued in order to estimate its total worth in the complex process of codling moth control. The factors in order are: its killing power on, first, the calyx worms of the first brood; second, the side worms of first brood; third, the second brood calyx worms, and fourth, second brood side worms. Then there is still another factor that is more important to consider than some of these and that is, that every worm killed in the first brood prevents the appearance of a number of worms in the second brood. Where the second brood is small as compared with the first, as it is in the New England states, then this factor is small—but when the second brood is larger as it is with us, then this factor becomes very important and must be recognized. The simplest method of accomplishing this is to accord to the first brood results a much larger value than to the second brood ones. This has not been done in working up the year totals of the tables, as they are based on actual worms present in the different broods, which added make the year total. In making comparisons of the value of sprays, this factor should, however, be considered. The relative value of the

TABLE No. 15—EFFICIENCY SUMMARY.

	1st BROOD			2d BROOD			YEAR TOTAL			Sprays Applied
	Calyx	Side	Total	Calyx	Side	Total	Calyx	Side	Total	
Lead Arsenate, 5 Lbs.										
	100	____	96	98	____	____	99	____	____	1-0-1
	99	____	92	99	____	____	99	____	____	1-1-0
	100	____	83	96	____	____	98	____	____	1-0-0
Avg.	100	____	90	98	____	____	99	____	____	
	79	____	76	55	____	____	65	____	____	0-1-1
	78	____	65	67	____	____	73	____	____	0-1-0
	43	____	35	21	____	____	20	____	____	0-0-1
Lead Arsenate, 2½ Lbs.										
	100	____	90	89	____	____	92	____	____	1-0-1
	95	____	76	77	____	____	83	____	____	1-1-0
	98	____	74	75	____	____	83	____	____	1-0-0
Avg.	98	____	80	80	____	____	86	____	____	
	55	____	52	31	____	____	41	____	____	0-1-1
	47	____	42	35	____	____	40	____	____	0-1-0
	0	____	3	0	____	____	0	____	____	0-0-1
New Compound, 5 Lbs.										
	75	____	51	40	____	____	53	____	____	1-0-1
	78	____	54	55	____	____	61	____	____	1-1-0
	68	____	31	43	____	____	51	____	____	1-0-0
Avg.	74	____	45	46	____	____	55	____	____	
	44	____	33	0	____	____	14	____	____	0-1-1
	34	____	23	1	____	____	14	____	____	0-1-0
	7	____	10	16	____	____	12	____	____	0-0-1
New Compound, 2½ Lbs.										
	52	____	39	36	____	____	41	____	____	1-0-1
	67	____	23	16	____	____	34	____	____	1-1-0
	39	____	10	0	____	____	8	____	____	1-0-0
Avg.	53	____	24	17	____	____	28	____	____	
	13	____	13	0	____	____	6	____	____	0-1-1
	32	____	20	38	____	____	35	____	____	0-1-0
	0	____	0	0	____	____	0	____	____	0-0-1

other factors will depend on the relative number of worms present in each case. The number of worms going into the calyx is much larger than those going into the side, so that efficiency in the calyx is much more important than side efficiency. More of the first brood worms go into the calyx cup than of the second, so that the efficiency of an early spray against the calyx wormy of the first brood is more important under our conditions than all of the rest of the work it does.

A study of the individual tree records, or the summaries in tables Nos. 11 and 12 will show, however, that the efficiency of a spray against the first brood calyx worms is also an index of its efficiency against the second brood calyx worms.

Single Sprays Compared.

Comparing the relative efficiency then of the first three sprays when used alone, we get table No. 16.

Table No. 16.—Relative Efficiency of First, Second and Third Sprays—(L. A. 5 Lbs.).

	Calyx Efficiency First Brood	Calyx Efficiency Second Brood
First Spray (calyx)_____	100	96
Second Spray (calyx)_____	78	67
Third Spray, 1st brood cover	43	21

This table brings out in a striking and definite manner the great superiority of the first spray in general efficiency and shows why this spray should never be neglected.

Almost equally suggestive is the second spray only (0-1-0), section of table 11 showing calyx efficiency as follows:

	Calyx Efficiency First Brood	Calyx Efficiency Second Brood
S. Orchard, 2nd spray applied early	97	88
W. Orchard, 2nd spray intermediate	87	64*
N. Orchard, 2nd spray quite late__	69	69

Note.—The average given in table 11 is for the three orchards. In table 15 only the last two are averaged so as to compare with the other combinations lacking the first spray.

*The second brood results were interfered with by doubling up worms on this orchard.

Where it is seen that the time of application is the important factor in determining the efficiency. Even where applied very early the efficiency of the second spray is seen to be much lower than the average of the first.

The Best Combination of Sprays.

The best combination of sprays under very wormy conditions cannot be as easily shown, as there are still other factors entering, and still other combinations besides those shown. The total first brood efficiency as shown in table 11 indicates that the first calyx spray and the first brood cover spray combined are most efficient against that brood. The total efficiency of 96 per cent shown for this combination is one of the highest records ever made, and is very gratifying when the heavy infestation of the orchards is considered.

High Efficiency Shown.

It must be remembered in studying the above records that they were obtained under excessively wormy conditions. These orchards had borne large crops of wormy fruit the previous year, and owing to the frosts in the spring were now bearing very light crops, many trees having no fruit on at all. All of the worms of the previous large crop were now concentrated on the relatively few apples of this season. Under such conditions only the most efficient methods would be able to produce any sound fruit at all.

Table A shows that these orchards averaged about four worms to each apple. A spray with a killing power of 75 per cent would, under these conditions, have killed three of these worms and left one to each apple, which would of course have been wormy, and the spray would have been called a failure. This same spray applied to an orchard in which there were only 40 worms to 100 apples would have killed 30 out of the 40 worms, leaving only 10 worms to each 100 apples, or 90 per cent of sound fruit, and the spray would have been considered fairly successful.

When the above conditions are taken under consideration and we still note that the standard sprays in table No. 11 gave 99 and 100 per cent calyx efficiency in the first brood and 99 per cent calyx efficiency for the year, regardless of the number of

worms that came to the apples, it will be appreciated that these records show the highest efficiency ever published. Omitting the Woodbury orchard, where, as has been explained, the weaker compounds were used too extensively, and we see that with two sprays, including the first one, the total efficiency shown for the year was from 90 to 93 per cent, even under conditions where it was impossible to show the efficiency actually obtained.

Summary and Conclusions.

The only thorough test of the value of a method of spraying or of a particular compound is to subject it to as severe conditions in the test as it will ever meet in ordinary practice.

Western Orchards, if unsprayed, would average from 2 to 4 or more worms per apple except in years of exceptionally heavy crops, therefore, methods and poisons must be able to successfully meet these conditions.

The Great Majority of the first brood worms and over one-half of the second brood ones enter the calyx cups, therefore the most efficient spray will be the one that destroys the greatest per cent of these worms.

The Second Brood of worms in Utah is ten or more times as large as the first; therefore, each first brood worm killed has saved ten worms in the second brood.

The Killing Efficiency of a given method or of a given poison can, therefore, be very accurately measured by the calyx efficiency in the first brood.

The Killing "Efficiency" of a given spray is a much better measure of its value than the per cent of wormy apples in the orchard.

The Efficiency of a given spray on the first brood can be accurately measured without regard to the number of worms in an orchard on the method of checking, provided there are no more worms than apples.

The First Calyx spray (1st spray) is by far the most valuable single spray that can be applied, killing 98 per cent of all worms entering the calyx during the year, and over 99 per cent of those in the first brood.

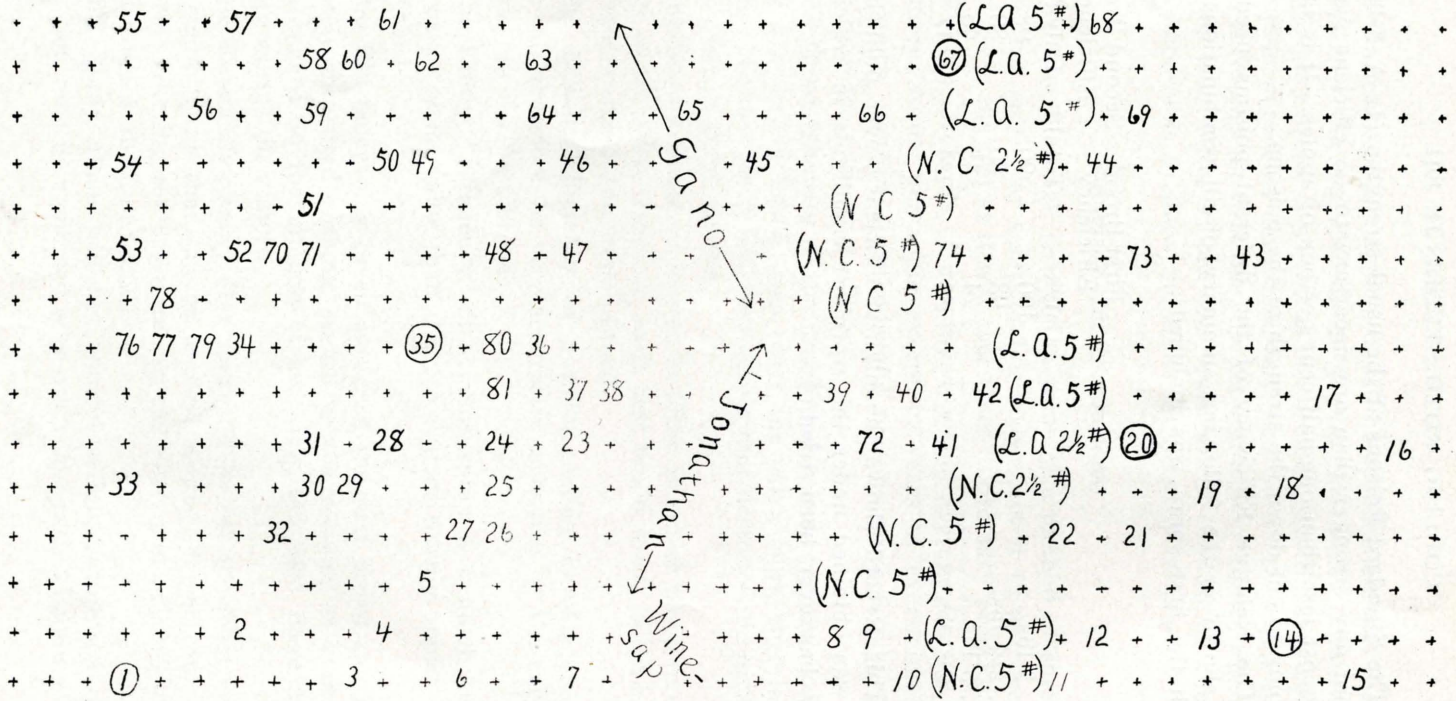
This Spray alone will not control seriously infested orchards, but must be combined with other sprays and banding.

The Standard Poisons at the usual strengths (L. A. 5 lbs.) are not any stronger than are necessary to do efficient work. They cost less than one-half cent per box of apples. It is false economy to cut down the strength of the poisons.

The Relative Efficiency of the different poisons used is well shown in the following summary of all combinations in which the first spray was included:

	First Brood Efficiency		Second Brood Efficiency
	Calyx	Total	Calyx
L. A. 5 lbs.	100	90	98
L. A. 2½ lbs.	98	80	80
N. C. 5 lbs.	74	45	46
N. C. 2½ lbs.	53	24	17

This Record shows the highest efficiency ever published, and was obtained under the wormiest conditions in which a spray has ever been tried.



The Woodbury Orchard.—Showing location of experimental trees and distribution of different poisons used. Note the large amount of N. C. used.